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UTILIZATION OF FUZZY LOGIC APPROACH FOR EVALUATING STUDENT'S PERFORMANCE: A CASE STUDY AT SECONDARY SCHOOL

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Abstract

This paper discusses a systematic alternative in evaluating student's performance at school, specifically in identifying eligible student to be awarded as the best student by adapting a mathematical fuzzy logic approach. The common approach in evaluating student's performance at school is merely based on the academic achievement. In the real-life situation, students are required to possess other characteristics such as leadership and other soft skills. Thus, in this fuzzy logic approach, the criterions to be considered are the examination score, the roles and responsibilities that the students hold and their behaviour at school. Often, the decision making in the current approach lead to time consuming, unfairness and bias as the assessment of student's performance encompassing individuals with different thoughts and perceptions. The computational evaluation of student's overall performance is solved using MATLAB based on the data collected at one of the secondary schools in Mukah. The "if then rules", which is based on human judgement is applied to identify the best student. The result shows that the highest output value scored by the student is 0.608 where the student is likely belonging to the "Good" categories in the membership function. It was found out that this study is able to contribute in solving the problem involving uncertainty and vagueness in the process of selecting the best student to be awarded. The proposed approach has provided the value added in term of differentiating clearly score obtained by each student and their belongingness in the membership function.

Keywords: Student's evaluation, fuzzy logic, performance, membership function

Introduction

Fuzzy logic theory emerged during the twentieth century and was predicted to be applied extensively in many fields (Altrock, 1995). The use of fuzzy logic approach for the evaluation of teacher's and student's performance is still newly introduced in academic environment. However, it has reached a wide range of application areas in educational systems to evaluate the student's academic performance, by including the evaluation of curriculum and that of the educators.

Students cannot be evaluated by relying solely on the conventional method as there are factors, other than academic that needs to be considered. Thus, grouping or clustering students using cognitive as well as affective factors into different categories, and then defining performance measure may offer a more realistic approach. The use of fuzzy logic approach in performance evaluation is complicated and requires advanced software. However, compared to the conventional method which adheres to constant mathematical calculation, fuzzy logic evaluation is flexible and provides many evaluation options.

The use of fuzzy approach has been widely applied due to its useful function in performance evaluation system. It allows the integration of other variables that could influence the student's performance in their learning institutions. By identifying these factors, it can justify the selection of a group of students who have the potential to be the best student that excels not only based on academic, but also other contributing factors. When they graduate with excellent academic result and good soft skills, these students become the potential source of manpower in developing our nation's economy. Student's performance in secondary school should be a concern not only to the academics and educators, but also to corporations which are often said to be the "end-user" in the supply chain of graduates for the labour market. Therefore, to achieve the objective of this study, the framework of implementing mathematical fuzzy logic in evaluating the performance criteria for secondary school student's performance evaluation has been developed**.**

Methodology

Figure 1 represents the sampling techniques and analytical procedures adopted in this study. The gap analysis for selected case studies was carried out with the purpose to review all the information related to the issues that needs to be analyzed. This includes the criteria to be considered in student's performance evaluation and the adaptation of Fuzzy Logic approach. Then, the parameters that will be used will be identified.

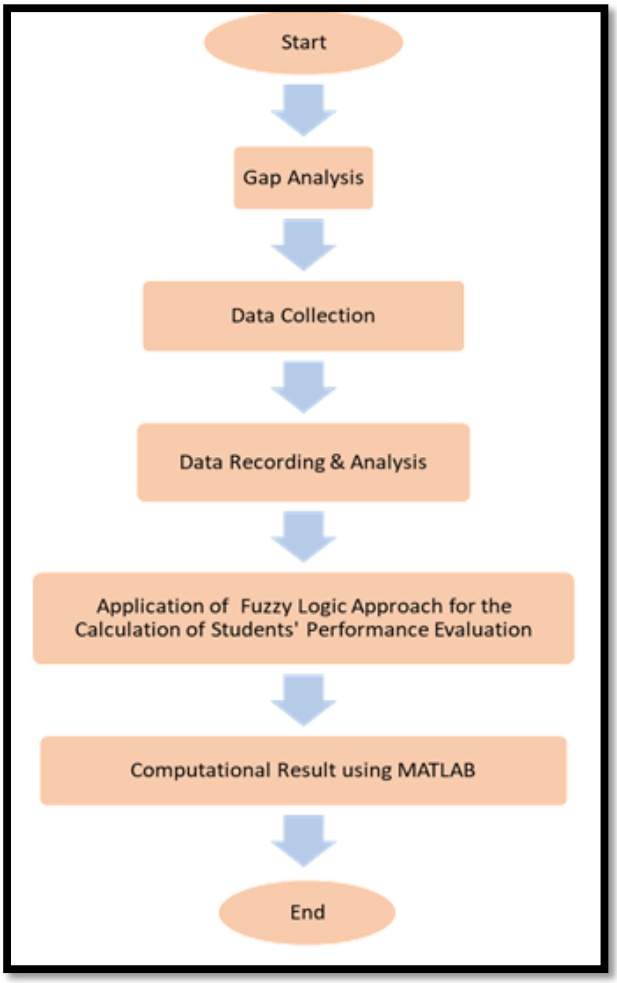

Figure 1. Flow Chart of Sampling Techniques and Analytical Procedures

Secondary data has collected from the selected secondary school in Mukah, Sarawak with the help from the respective teachers. All the collected data is recorded and analyzed using Fuzzy Logic method. The following are the stages involved when using fuzzy logic model.

Crisp Value (Data)

Criteria that have been evaluated are:

a) Academic performance (based on the student's examination score)
b) Role and responsibilities (including position hold by the students, involvement in co-curricular and also involvement in an outdoor event competitions)
c) Student's behaviour (including the student's behaviour towards learning process in the class, their attendance and disciplinary act)

Fuzzification

Fuzzification is a process to generalize the crisp data into fuzzy inputs. The data will be categorized using variable known as linguistic expression, for example very good, good, average and others. Scale is used to represent the linguistic expression as shown in the tables below:

Table 1
Student's Exam Score Performance

Linguistic Expression	Interval
Very Low	[0 0 25]
Low	[0 25 50]
Average	[25 50 75]
High	[50 75 100]
Very High	[75 100 100]

Table 2
Student's Roles & Responsibility Performance

Linguistic Expression	Interval
Very Low	[0 0 2.5]
Low	[0 2.5 5]
Average	[2.5 5 7.5]
Very Good	[5 7.5 10]
Excellence	[7.5 10 10]

Table 3
Student's Behavior Performance

Linguistic Expression	Interval
Poor	[0 0 1]
Average	[0.5 1.5 2.5]
Good	[2 3 3]

Table 4
Student's Overall Performance

Linguistic Expression	Interval
Poor	[0 0 0.25]
Average	[0 0.25 0.5]
Good	[0.25 0.5 0.75]
Very Good	[0.5 0.75 1]

Each input variable is assigned in a triangular membership function using MATLAB Fuzzy Logic Tool as shown in Figure 2.

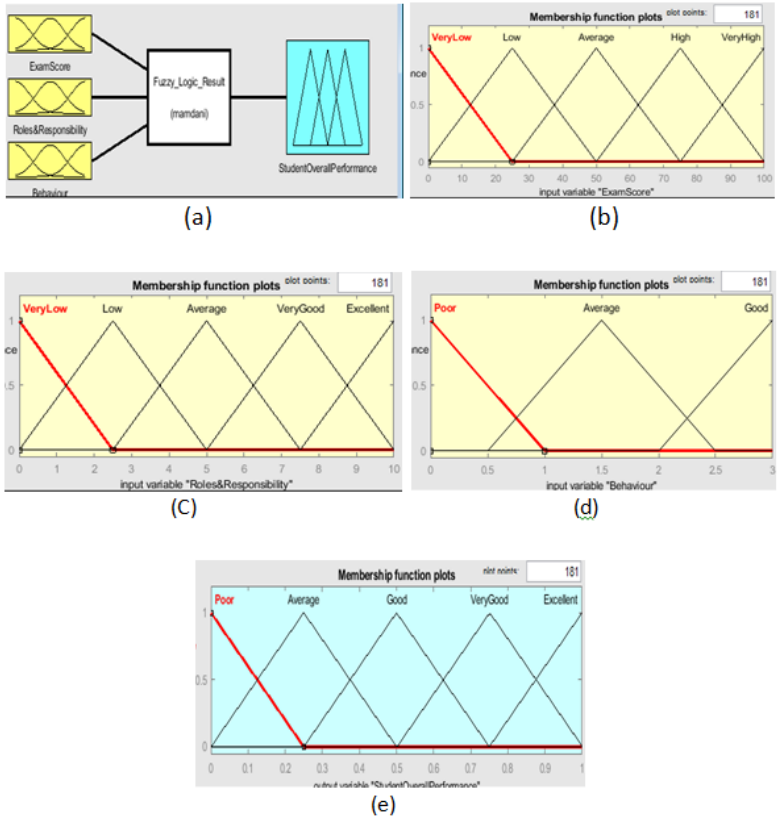

Figure 2. The Computational Experiment Using MATLAB Fuzzy Logic Tool

(a) The Setting of Input and Output Parameter
(b) Membership Function for Exam Score
(c) Membership Function for Roles and Responsibility
(d) Membership Function for Student's Behavior Toward Learning
(e) Membership Function for Student's Overall Performance

Developement of Fuzzy Rule

'If-Then' rule is used in inference process to determine the input and output of the membership function. Before applying the rule, the rule weightage must be determined first. The 'If-Then' rule can be formulated depending on the importance of the particular input.

Defuzzification

Defuzzification is a process of converting fuzzy number into a crisp values. The performance value for each students is obtained using the triangular fuzzy technique. The computational results obtained using MATLAB will then be interpreted and analyse.

Literature Review

The use of fuzzy evaluation method or fuzzy approach does not only applicable for students but also for the employees in any company, teachers, staffs and so on. Employees evaluation represents the decision which often involves subjective information about them based on parameters including responsibility, attitude, leadership qualities, communication skills, commitment and creativity whereas higher educational institutions rely on performance of teachers and many factors like teaching, student's feedback, use of innovative techniques in teaching learning process, research and publications that affect the quality of teaching. Table 1 shows the summary of several studies done by researchers regarding to the evaluation of student's performance and the methods used.

Table 5
Findings from Previous Researchers

Year	Author	Significant Findings
1995	Ranjit Biswas	The aim of educational institutions should be to provide the students with the evaluation reports in connection with their test/examination as sufficient as possible, may be with unavoidable error as small as possible, in a specifically pointed form as a numerical number instead of big interval valued form, as the latter does not satisfy the students. In the present paper the researchers have initiated the idea of vector valued evaluation of each question leading towards fern (fuzzy evaluation method), a computer based fuzzy approach, for overall evaluation of any answer script of the students. Furthermore, the concept of fem has been generalized by using matrix-valued marking, to introduce gfem (generalized fuzzy evaluation method).
2001	Sunghyun Weon and JiniI Kim	This paper suggests that a fuzzy evaluation method is suitable for various fuzzy environments, leading a research on the 4th graders of an elementary school. Various fuzzy environments, as a result, are reflected in this experiment to evaluate students just like a human teacher does intuitively. The lingual results this method gives to students, GOOD or BAD, are useful because it gives more flexible evaluations to students.
2005	Ervina Alfan and Md Nor Othman	This study reveals that the knowledge obtained from subjects like economics, mathematics and accounting is essential in assisting the students in getting, through the business and accounting degree program. Hence, efforts should be directed at increasing the students' comprehension in these subjects to reduce the number of student's drop-outs in the faculty. However, the results from this research indicate that there are other variables that could influence the students' performance in the university. Identifying these factors is vital to ensure

Year	Author	Significant Findings
		that the students who are qualified to enter the degree program do graduate with excellent results.
2009	Norhidayah Ali, Kamaruzaman Jusoff, Syukriah Ali, Najah Mokhtar and Azni Syafena Andin Salamat	The purpose of this research is to identify and examine factors that affect students' performance at UiTM Kedah. The researchers found that four factors are positively related to students' performance that is demographic, active learning, students' attendance and involvement in extracurricular activities. The results indicated that demographic variables are observed to have the positive correlation with the CGPA; that is 0.094. It means that those students whose parents are highly educated and have high income have greater CGPA.
2011	Wan Suhana Wan Daud, Khairu Azlan Abd Aziz, and Elyana Sakib	The students' performance is denoted in the form of scores and linguistic term, which involves elements of uncertainty. Thus, in this study, the Fuzzy Evaluation Method had been applied in evaluating the students' performance in oral presentation. Based on the evaluation, this method could provide additional information on the students' performance for any kind of criteria. Besides that, the usage of linguistic terms is beneficial so that the students can work harder in order to obtain the best level of performance for the future oral presentations. Hence, this approach can be applied as an alternative method in evaluating the students' performance in the oral presentation that may provide a simplicity and manageability during the process.
2013	Imtiaz Ahmed, Ineen Sultana, Sanjoy Kumar Paul, and Abdullahil Azeem	In this research, a fuzzy model for performance evaluation is proposed and using historical data of a company the performance index is obtained by which the best employee is selected. Here, 20 input variables for five employees are considered to determine the result. Some other input variables may also be considered to find the result which depends on type of the purpose of the evaluation system of company. For each input and output variable triangular membership functions are considered to design the model. Other membership functions also may be considered to design the model. As based on the performance index obtained by the model, selecting people for promotion, training, performance bonus, and performance-based pay awards could be accomplished through a transparent process. The complex middle calculation of fuzzy logic is done entirely by MATLAB software. The proposed approach is very convenient to perform comparing to other available approaches like analytical hierarchy process, weighted average method that require substantial calculation if at a time a good number of performance criteria is considered as the basis of evaluation.

Year	Author	Significant Findings
2015	Izzaamirah Binti Ishak	The author concludes that the fuzzy logic approach is compatible and comprehensive in evaluating the student performance for calculation subjects. In addition, fuzzy logic provides more flexibility and allows matching of individuals to be determined on a continuous scale as well in an integer scale, whereas classical approach is based on a constant mathematical rule, using the average method. From the result and discussion indicates when the students did not score subject-X and Subject-Y or neither the performance value in calculation subjects will be affected. Only seven students perform well in both subjects according to performance value more than 0.75. However, only two subjects were taken into consideration in this research work.
2015	Zamali Tarmudi, Mazalan Sarahintu, and Ajis Lepit	In this study, the intersection of fuzzy goals and constraints concept had been applied in evaluation process for choosing the best Pre-Diploma (Science) students at UiTM Sabah. Since the evaluation generally involve uncertainty, it is important to incorporate the fuzzy approach to derive precise results in any proposed method. From the numerical example, the proposed method is beneficial in terms of evaluation perspective. The extremely significant fuzzy environment has been utilized to derive the membership values in the range of [0, 1] which provide some straightforward procedures by constructing the relevant membership functions. Furthermore, although the given empirical study may derive a different and/or same result for other cases, it still depends greatly on how the evaluators evaluate the relevant attributes during the judgment process. Also, the approach has unique advantage in the sense that it can distinguish clearly for every single score mark obtained by the students. Thus, it gives highly beneficial for problem solving under uncertainty data sets environment.
2015	Dr. V. Anbarasu, A. Jenitha and J. Jerin Yulit	This paper demonstrates the application of fuzzy logic in the employee evaluation process. The system has been implemented using MySQL database which was used to maintain the data. Employee evaluation represents the decision which often involves subjective information about them based on many parameters like responsibility, attitude, leadership qualities, communication skills, commitment, creativity, etc. While evaluating an employee for such parameters the scores given by the reviewer are approximated as they are based on judgment making ability of the reviewer. The use of fuzzy logic, allows them to express themselves linguistically and to make assessments that

Year	Author	Significant Findings
		are subjective in nature and helps represent a higher level of abstraction originating from our knowledge and experience, thereby providing a simple way to draw definite conclusions from ambiguous, vague, imprecise information.
2016	Mamatha Guruprasad, Sridhar R, and Balasubramanian S	Higher educational institutions rely on performance of teachers and many factors like teaching, student's feedback, use of innovative techniques in teaching learning process, research and publications affect the quality of teaching. The University Grants Commission prescribed format necessitates measurement of performance as Academic Performance Indicator (API) which has quantitative and qualitative parameters. The conventional methods are not effective in measuring the performance under uncertainty which can lead to improper decision making. The use of advanced technology such as soft computing models like fuzzy logic in assessment of performance of faculty facilitates expression of linguistic variables help arrive at definite conclusions in the presence of vague, uncertain, ambiguous data. Proper evaluation can help identify the strengths and weaknesses of faculty and provide opportunities for improvement and skill development. This model can help make decisions at times of promotions, salary hike, increments, even punishment, grievance handling, etc.
2016	Alibek Barlybayev, Altynbek Sharipbay, Gulden Ulyukova, Talgat Sabyrov, and Batyrkhan Kuzenbayeva	Correlation of the results to find out how strong the relationship between the values of the results. The most known Pearson correlation coefficient, that means the level of line dependence between variables. As we see the method for calculating the performance by Fuzzy computing has other methods has Strong positive linear relation. The evaluation student performance was proved by Fuzzy computing more palatable, since the arithmetic mean, Kazakh, Liverpool systems use formulas other variations not, and to change the final assessment, simply change the formula for calculating the evaluation and Fuzzy computing based on logical inference rules. In addition, Fuzzy computing is an internationally proven a powerful mathematical tool, and it should be used everywhere.
2017	Serife Z. Eyupoglu, Konul Jabbarova, Tulen Saner	Their study applied fuzzy rules-based approach in evaluating job satisfaction in an organization. Computational system was suggested to process linguistic information on factors affecting overall job satisfaction. It is also able to approximate reasoning based on fuzzy rules model to determining overall job satisfaction.

From the previous findings, it is shown that there are various ways in evaluating the student's performance. Fuzzy Evaluation Method or Fuzzy Approach can be considered as popular selection and has been widely used around the world due to its useful applications. Secondary school is considered as important stage before the students enter the higher learning institutions. Therefore, student's performance in secondary school should be a concern not only to the academics and educators, but also to corporations which are often said to be the "end-user" in the supply chain of graduates for the labour market. Evaluating student's academic performance using proper techniques is important in ensuring a fair assessment of their qualities (Tarmudi, Sarahintu and Lepit, 2015).

Findings

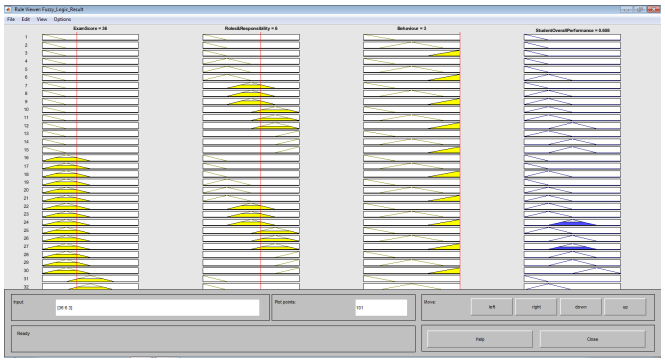

Figure 3. Example of the Rules and Student's Overall Performance

Rule viewer for the highest fuzzy value is shown in Figure 3 above, where the Examination Score is 36, Roles & Responsibility is 6 and Behaviour is 3. The performance value is 0.608, which is Good corresponding to the linguistic term for the output defined earlier. The surface view of student is presented in Figure 4.

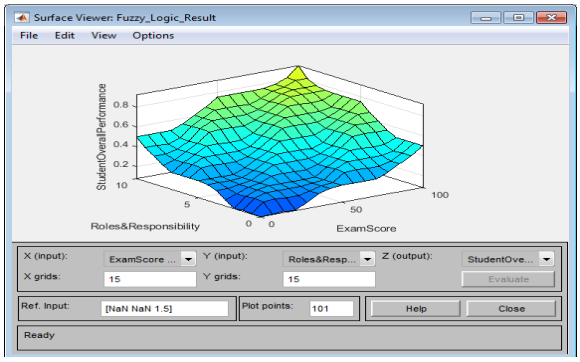

Figure 4. Surface Viewer

Table 6 shows the result obtained by selecting the top 10 students based on the score from the membership values.

Table 6
Top 10 Students Ranking Based on Fuzzy Value

Rank	Fuzzy Value	Student
1	0.608	1
2	0.57	2
3	0.5	18
4	0.5	19
5	0.492	17
6	0.395	3
7	0.395	4
8	0.395	5
9	0.372	8
10	0.369	21

Discussion

Evaluation of student's performance is a process of making judgement on a student based on several elements such as examination, assignment, test, quiz, research work and so on (Daud et al, 2011). Evaluation of student academic performance usually consists of several components, each involving several judgments often based on imprecise data. Thus, due to the imprecision problem, a systematic alternative was introduced to evaluate the students' performance in terms of their academic since the students' performance normally is denoted in the form of scores and linguistic term, which means it involves with the elements of uncertainty.

Proper evaluation of students can assist in acknowledge their own strengths and weaknesses to improve better in their overall performance in both academic and soft skills. It is also can be a preparation for them as they begin to pursue their study in the higher level, and to survive in the work life challenges. It is very important for individual nowadays to have the capability in problem solving and communication skills, to name a few. Excel only in academic or examination score is not an assurance that the individual will excel in working line too.

In the future research, the researcher can tackle into more detailed aspects or attribute in evaluating student's performance. The researcher also can target a primary school student as a respondent, essentially to improve student's overall performance from younger stage. The knowledge gained from this study is expected to contribute to the school in terms of introducing a systematic alternative method in evaluating student's performance.

Conclusion

In this paper, fuzzy logic approach has been utilized to evaluate the performance of secondary students. Fuzzy logic, a mathematical technique of set-theory can be applied to many forms of decision-making including research on engineering and artificial intelligence. The proposed approach has the advantage in term of differentiating clearly score obtained by each student and their belongingness in the membership function. It was found out that this study be able to contribute in solving the problem involving uncertainty and vagueness in the process of selecting the best student to be awarded.

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